United States Patent [19]

Kupsky

[11] **3,743,879**

[45] **July 3, 1973**

[54] **COLD CATHODE DISPLAY PANEL HAVING A MULTIPLICITY OF GAS CELLS**

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[73] Assignee: **Burroughs Corporation**, Detroit, Mich.

[22] Filed: **Dec. 31, 1970**

[21] Appl. No.: **103,320**

Related U.S. Application Data

[63] Continuation of Ser. No. 764,984, Oct. 2, 1968, abandoned.

[52] **U.S. Cl.** ..... **313/108 B**, 315/169 TV

[51] **Int. Cl.** **H05b 37/00**, H01j 1/62

[58] **Field of Search** ..... 315/169 TV, 169; 313/108 B, 109.5, 100

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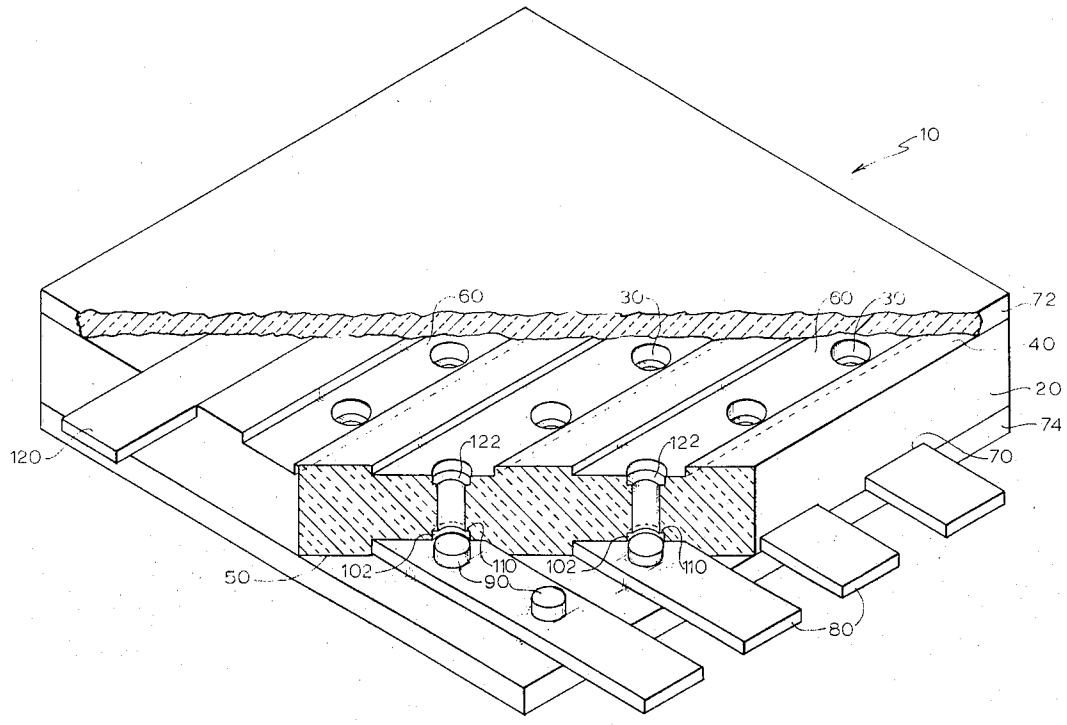
Primary Examiner—Roy Lake

Attorney—Kenneth L. Miller and Robert A. Green

[57] **ABSTRACT**

A flat display panel comprising a plurality of gas-filled light-producing cells, each having at least two electrodes for energizing the cell. The panel includes various structural features including projections on the electrodes which extend into the cells to aid in positioning the electrodes and maintaining alignment between the electrodes and cells, the shaping of the electrodes to achieve minimal leakage between cells, the provision of structural features to minimize cathode sputtering, etc. Various arrangements are also described for generating different colors of light.

44 Claims, 26 Drawing Figures



Patented July 3, 1973 3,743,879

6 Sheets-Sheet 1

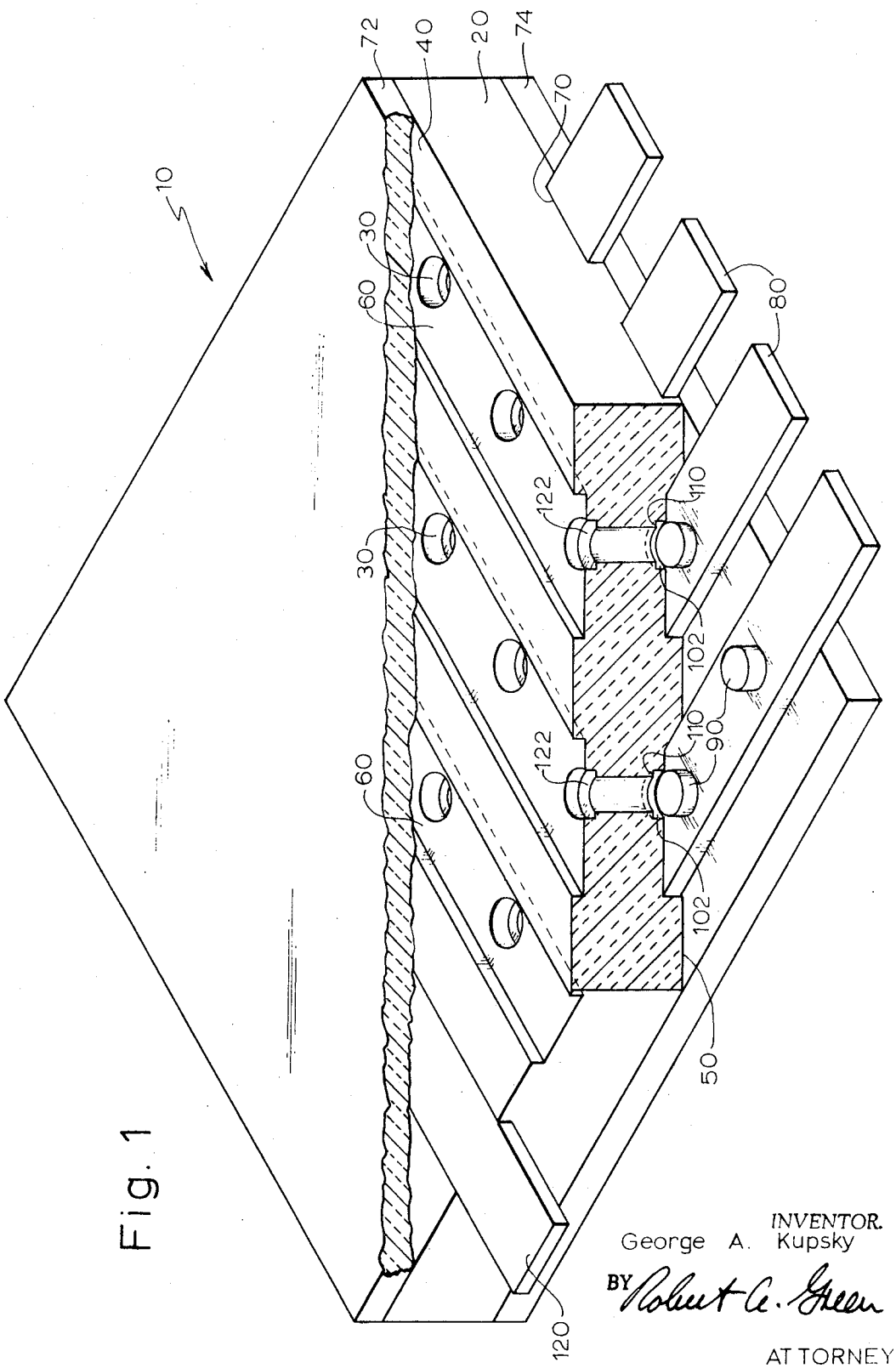


Fig. 1

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Fig. 2

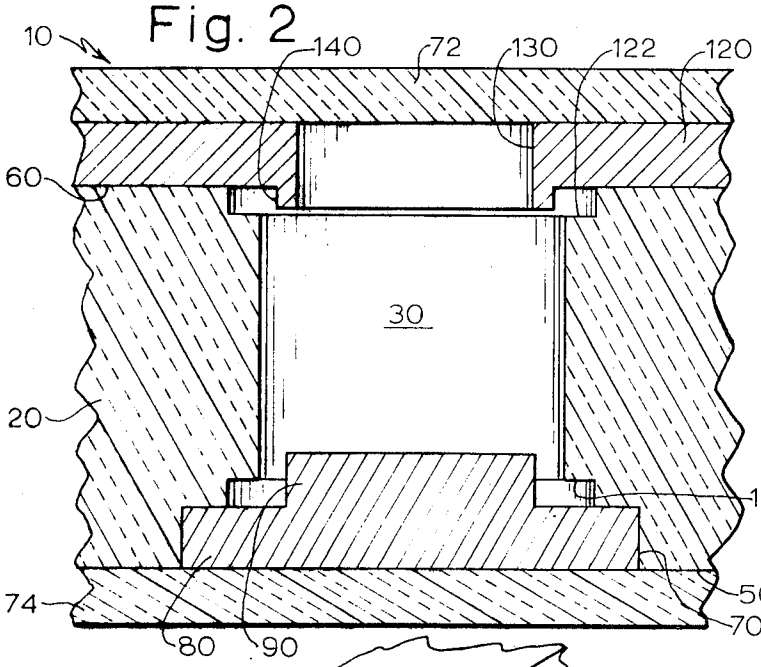


Fig. 4

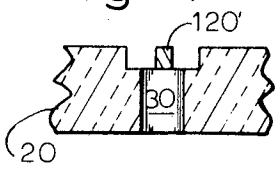
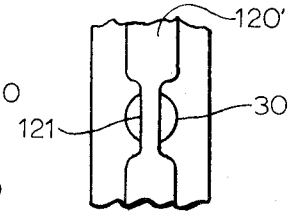


Fig. 5



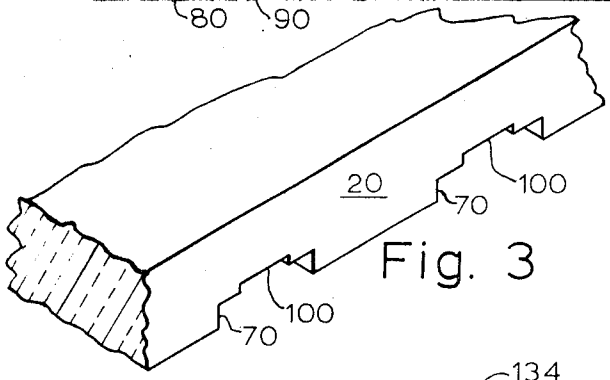


Fig. 3

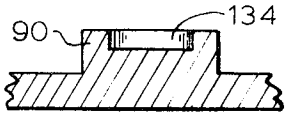


Fig. 6

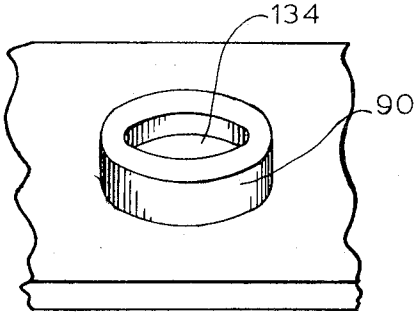


Fig. 7

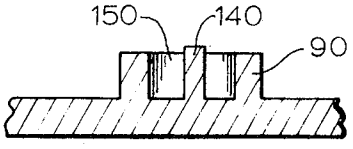


Fig. 8

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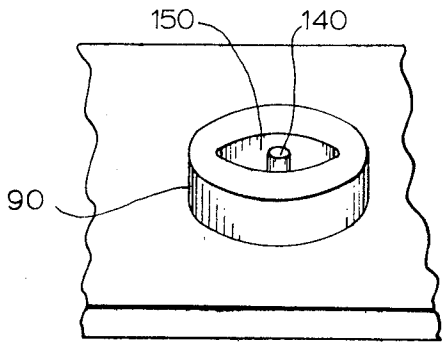


Fig. 9

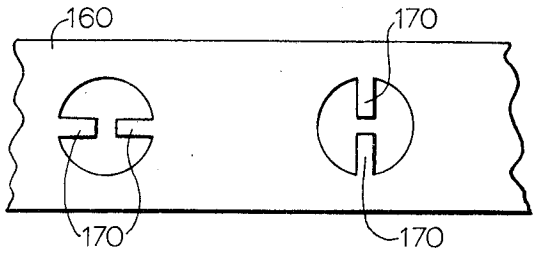


Fig. 10

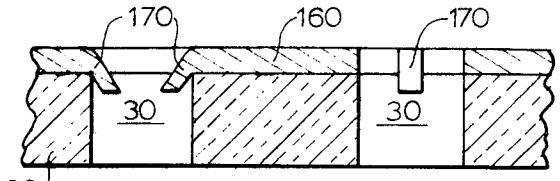


Fig. 11

Fig. 12



Fig. 13

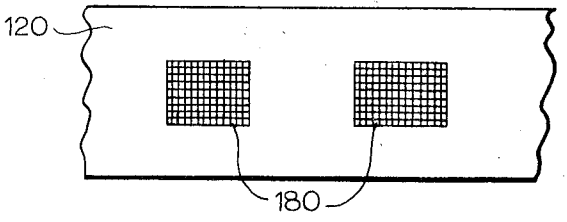
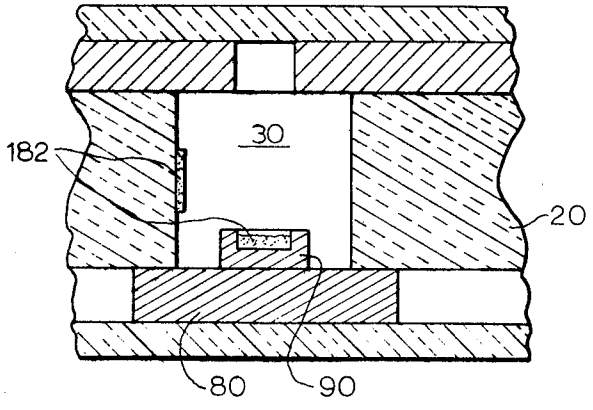


Fig. 14



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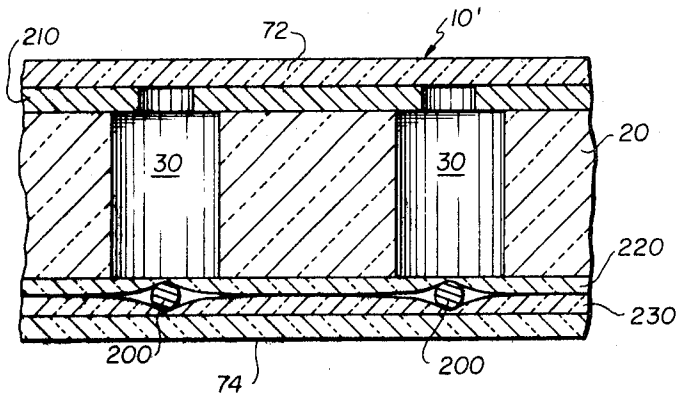


FIG. 15

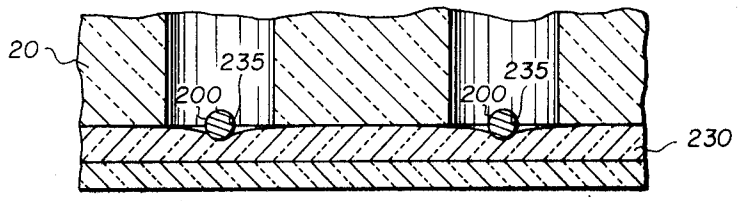


FIG. 16

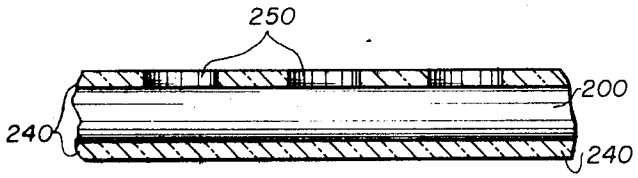


FIG. 17

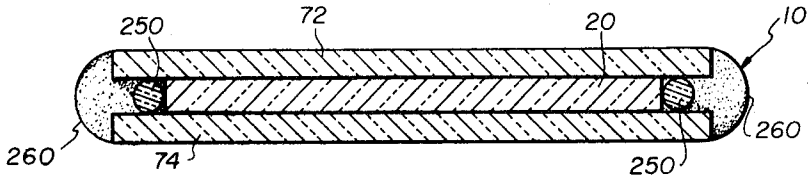


FIG. 18

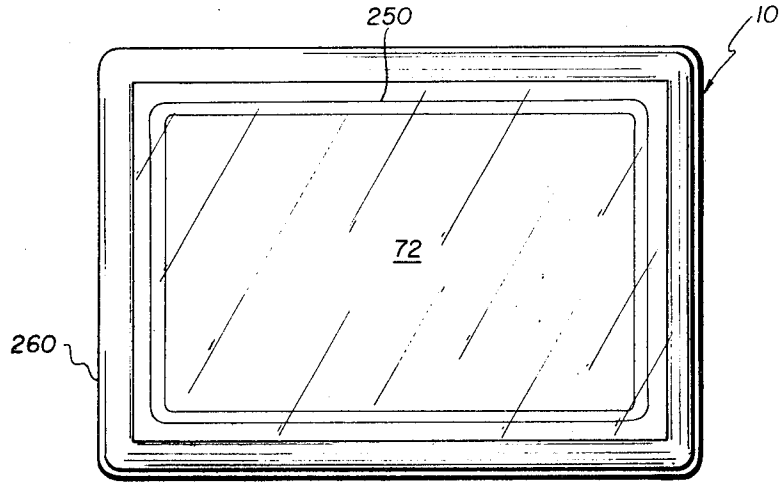


FIG. 19

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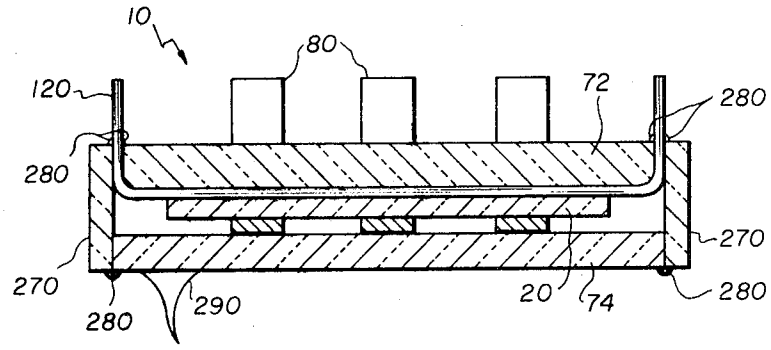


FIG. 20

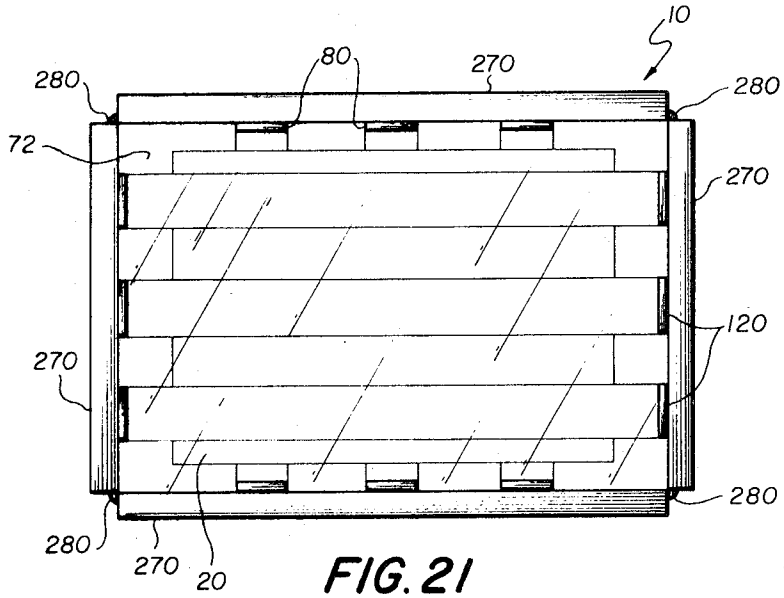


FIG. 21

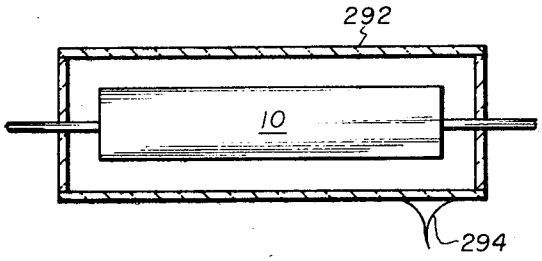


FIG. 22

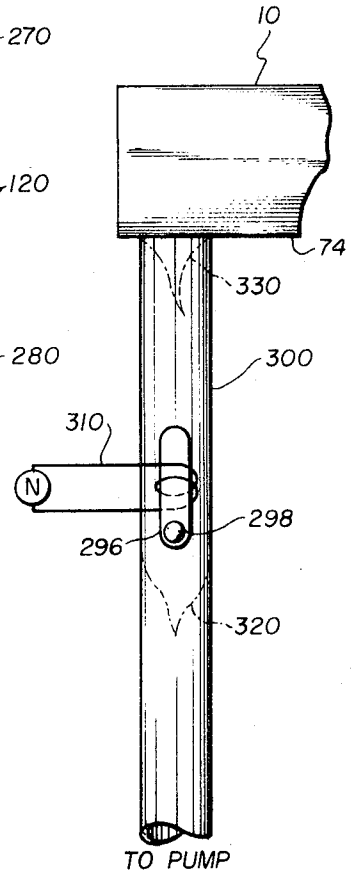


FIG. 23

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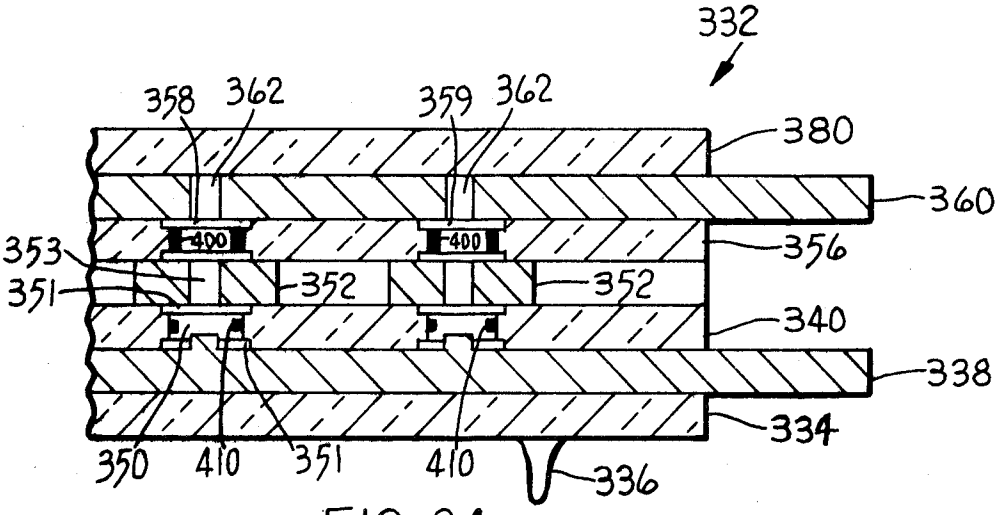


FIG. 24

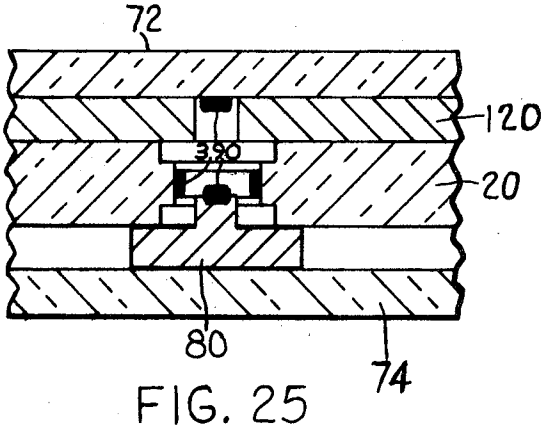


FIG. 25

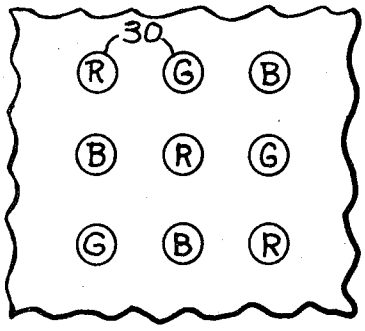


FIG. 26

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COLD CATHODE DISPLAY PANEL HAVING A MULTIPLICITY OF GAS CELLS

This is a Continuation of Application Ser. No. 764,984, filed Oct. 2, 1968, now abandoned.

BACKGROUND OF THE INVENTION

Flat panel, matrix-type light-generating devices have been known in the literature for some time. However, these known devices appear to have been laboratory devices, since even though there has been a need for such flat panel light-producing devices in all sizes, they have not been available commercially. The present invention provides a practical, commercial, light-producing panel which can be made with relative ease in almost unlimited sizes and is capable of generating one or more colors of light.

DESCRIPTION OF THE DRAWING

FIG. 1 is a perspective view, partly in section, of a display panel embodying the invention;

FIG. 2 is a sectional view of the device of FIG. 1 showing one gas cell thereof;

FIG. 3 is a perspective view of a portion of the device of FIG. 1 showing a structural modification;

FIG. 4 is a sectional view of a cell and one anode construction usable in the invention;

FIG. 5 is a plan view of a cell and another anode construction;

FIGS. 6 through 11 illustrate different cathode constructions which may be used in practicing the invention;

FIGS. 12 and 13 illustrate another anode construction;

FIG. 14 is a sectional view of a cell construction illustrating a modification for facilitating photoelectron emission;

FIG. 15 is a sectional view of a modification of the panel of the invention;

FIG. 16 is a sectional view of a modification of the panel of FIG. 15;

FIG. 17 is a view, partly in section, of an electrode useful in panels of the invention and particularly those of FIGS. 15 and 16;

FIG. 18 is a sectional view of a panel illustrating another modification of the invention;

FIG. 19 is a plan view of the panel of FIG. 18;

FIG. 20 is an elevational view of another modification of the invention;

FIG. 21 is a plan view of the panel of FIG. 20;

FIG. 22 is an elevational view of a panel embodying the invention and a packaging arrangement therefor;

FIG. 23 is an elevational view of a panel embodying the invention and associated apparatus used in the manufacture thereof;

FIG. 24 is a sectional view of another modification of the invention;

FIG. 25 is a sectional view of a cell of a panel in which light-emitting phosphor materials are used; and

FIG. 26 is a schematic plan view of a typical array of cells containing phosphor materials having different light-emitting properties.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A display device 10 embodying the invention, shown in FIG. 1, includes a central plate 20 of insulating material such as glass or ceramic which is provided with

rows and columns of apertures or cells 30. The central plate 20 has a top surface 40 and a bottom surface 50. The top surface 40 is provided with elongated, parallel slots 60, each of which is aligned with a row of apertures 30, and the bottom surface 50 is provided with parallel slots 70 which are aligned with columns of apertures 30. The slots 60 and 70 are wider than the apertures or cells 30, and row and column conductors 120 and 80 pass along the slots 60 and 70, respectively. The device 10 also includes top and bottom glass plates 72 and 74 which, along with plate 20, are usually rectangular. The row and column conductors extend beyond the edges of the plates so that electrical connection can be made to them.

In a typical panel 10, the central plate 20 is about 1 mm. in thickness, the top and bottom plates are about 1 to 3 mm. in thickness, and the cells are about 0.04 inch in diameter at a density of about 12 cells per linear inch. The slots 60 and 70 are about 0.05 inch wide and about 5 mils deep. Of course, other mechanical arrangements may be used.

The column conductors 80 include a plurality of cathode electrodes 90, which are formed by cylindrical elevations or buttons 90 of smaller diameter than the cells 30, and which extend into the cells a convenient distance. The column conductors 80 thus serve as cathode connectors or strips. Similarly, the row conductors 120 may be referred to as anode connectors or strips and include raised anode portions 140 (FIG. 2) which extend into the cells 30.

In order to prevent a continuous path of sputtered cathode metal from forming between the cathodes and anodes of the respective cells, it is desirable to provide an indentation in plate 20 surrounding the cathode button 90 in each aperture. This may be either a second slot 100 extending along the entire length of each slot 70 (FIG. 3), or 90. The circular slot 102 (FIG. 1) surrounding each cathode button 90. The recess thus provided serves to prevent the formation of a continuous shorting path of metal from a cathode through a cell 30 to the associated anode. A similar recess may also be provided at the anode end of each cell, either by means of an elongated slot (not shown) or by a circular slot 122 (FIGS. 1 and 2).

The anode strips are provided with viewing apertures 130 aligned with cells 30, and, as indicated, they may include annular rings or elevations 140 which surround the apertures 130 and extend into the cells 30. The cathode buttons 90 and anode rings 140 are dimensioned to provide the desired spacing between them and thereby to control one of the parameters which affects the operating characteristics of a cell. Modified anode strips 120' might also be used which are either narrower than cells 30 (FIG. 4) or have narrowed portions 121 over the cells (FIG. 5) to permit glowing gas in the cells to be viewed. The anodes might also comprise transparent metal films. Other anode arrangements might also be used.

The cathode and anode electrodes may be made of stainless steel, nickel, alloys of nickel-iron-chrome, etc. In one construction, the electrode strips are about 0.042 inch wide, 5 mils thick, and the elevations are about 5 mils high.

The seating of the cathode and anode strips in their respective slots provides automatic and easy mounting and alignment of these electrodes, and it also provides a favorable mechanical fit between the electrode strips

and the center plate **20** and the outer plates **72** and **74** such that leakage between cells is minimized. Of course, the anode and cathode strips might be seated in slots formed in the top and bottom plates, rather than in the central plate **20**, if desired, in which event, the raised electrodes on these strips would again provide automatic alignment with the cells **30**.

The current density in a fired or ON cell is related generally to the size of the active area of the cathode in the cell, and thus this parameter can be varied by altering the size of button **90**, as desired. In addition, other variations may be made in the cathode and anode electrodes. For example, referring to FIGS. **6** and **7**, each cathode button **90** may be provided with a central depression **134** so that the button becomes generally cup-shaped. This configuration may be further modified (FIGS. **8** and **9**) by shaping the button so that a central post **140** is provided surrounded by an annular depression **150**. This, in effect, represents a post within the cup of FIG. **6**.

The cathode might also each be formed of a strip of metal **160** (FIGS. **10** and **11**) having small portions cut out to leave small tabs **170**, which can be bent downward, as shown in FIG. **11**, so that each pair of tabs projects into a cell **30** and extends toward the opposite anode. This configuration is advantageous for mechanically locating and holding the cathode strips in place and for facilitating the initiation of current flow between the anodes and cathodes. The tabs **170** in adjacent cells **30** are preferably offset by about 90° from each other to provide a complementary locating and locking action, which makes the tabs more effective in seating and locking each strip in place.

In a modification of the anode electrodes, the anode strips **120** (FIGS. **12** and **13**) are provided with very finely apertured areas **180** which overlie the cells **30**. The areas **180** are comparable to fine mesh screens so that, in effect, the anode associated with each cell is a fine mesh screen. This configuration is particularly useful for trapping sputtered cathode metal, so that it does not reach the viewing window formed by plate **72**.

It is well known in the art that it is desirable in cold cathode glow devices to utilize a cathode metal which will readily emit electrons, particularly photoelectrons, to facilitate the generation of glow discharge. Nickel, stainless steel, alloys of nickel-iron-chrome, etc. have been found to be satisfactory as cathode materials. In the panel **10**, the cathodes might also be made of a metal impregnated with barium, cesium, or the like, materials which are known to have favorable electron-emitting characteristics.

In another arrangement for achieving electron-emitting efficiency, according to the invention and referring to FIG. **14**, a layer **182** of barium or cesium-containing compounds, or any other comparable material having a low work function, is deposited on the cathode electrodes, and/or on the anode electrodes, and/or on the walls of the cells **30**. Preferably, cathode strips having cup-shaped electrode elevations **90** are used, and the material **182** is deposited in the cups. Usually such compounds are insulators; however, during processing of a display panel containing one of these compounds, ion and particle bombardment causes free metallic barium, cesium, or the like to form, and this provides the desired photoemissive activity.

A modified panel **10'** shown in FIG. **15** includes center plate **20** having cells **30** and top and bottom plates **72** and **74**, respectively. The cathode electrode strips **200** in this case are wires which may be of generally circular cross-section and aligned with groups of cells as described above, and the anode electrode strips **210** may also be wires, or they may be flat strips as described above. In this embodiment of the invention, in order to minimize the likelihood of crosstalk due to light or particle passage between adjacent cells, the cathode wires **200** are placed between sheets **220** and **230** of a flexible, yieldable material such as fiberglass or the like. Fiberglass sheet **220** either has a suitable open mesh, or it is provided with apertures to permit the cathode wires **200** to be in direct contact with the gas in the various cells.

If the cathode wires **200** are placed in slots **235** in plate **20** (FIG. **16**), then only a single sheet of fiberglass **230** is required to intimately engage the cathode wires and prevent crosstalk. The cathode wires might also be semicircular in cross-section and set in slots in the lower surface of plate **20** as in FIG. **16** so that their flat surfaces are flush with the lower surface of plate **20**. The fiberglass sheet may be omitted in this latter case. This modification is not specifically illustrated.

If desired, fiberglass sheets may be used in all display panels described herein although they are not specifically shown.

In these embodiments of the invention using wire cathodes, in order to further improve cell isolation, the electrodes wires (FIG. **17**) may be coated with glass **240**, with the glass coating being removed only at the portions of the electrodes **250** which are in operative relation with the gas in cells **30**. This cathode construction may be used with or without fiberglass sheets, and, in fact, the principle of glass coating could be used with any cathode or anode construction.

According to one method of sealing together the various glass plates which make up display panels embodying the invention, a sealing material such as a glass frit, having a relatively low melting point and dispersed in a suitable binder, is used. One suitable sealing material or cement is known as Pyroceram. This material is applied in paste form to the edges of the glass plates around the periphery of the panel, and then the panel is heated to fuse the cement and thus to form the desired seal between the plates and the electrodes. Ordinarily, the center plate **20** is smaller in area than the top and bottom plates **72** and **74** which extend beyond the center plate on all four sides. It has been found that, under some circumstances, the sealing cement finds its way between the top plate and the center plate and/or between the bottom plate and the center plate, and, when the assembly is fired to form the seal, this intrusive cement may expand excessively and cause the plates to separate. This is an undesirable condition which may cause leaks or cracking of the plates when the panel is exhausted and baked out.

In order to solve this problem (FIGS. **18** and **19**), a sealing gasket in the form of a cord **250** of fiberglass or the like having a diameter about equal to or preferably somewhat larger than the space between plates **72** and **74**, is wound around the center plate between the top and bottom plates so that it blocks the cement **260** from finding its way between the top and bottom plates and the center plate. This arrangement insures a good final seal when the cement **260** is fused and the seal is formed. For convenience, electrodes are not shown in FIGS. **18** and **19**.

In another modification of the invention (FIGS. 20 and 21), a display panel 10 includes top and bottom plates 72 and 74, apertured central plate 20, and the anode and cathode electrodes 80 and 120. As above, the electrodes strips project beyond the edges of the rectangular plates. In this embodiment of the invention, the portions of the electrode strips which extend beyond the edges of the plates are bent so that they lie adjacent to, and in contact with, the edges of the top or bottom glass plates. The directions in which the electrodes are bent is a matter of choice, and would probably be determined by the arrangement used for mounting the panel on a chassis or printed circuit board or the like. Four elongated, rectangular insulating frame plates 270 of glass or the like are placed around the periphery of the panel, with each in contact with one edge of the panel. The frame plates are of any convenient thickness; they are about as long as the edge of the panel which they contact; and they are of a width such that they contact the top and bottom plates and the electrode strips which may be in contact with one of the plates.

A sealing cement 280 such as Pyroceram is applied to the area of contact between each glass frame plate and the plates 72 and 74 and between the adjacent ends of the frame plates. With the parts held together in any suitable fashion, the assembly is baked to fuse the cement and thus to seal all of the parts together in gas-tight contact. The panel is exhausted, baked out, and filled with the proper gas through tubulation 290.

The panel thus prepared has sealing material only between the frame plates 270 and panel plates 72 and 74 and between the adjacent ends of the frame plates 270 and adjacent portions of plates 72 and 74. Thus, the problems are avoided which might be encountered if sealing material is placed, or finds its way, between the plates 72 and 74.

This problem in sealing may also be avoided and other advantages may also be achieved by mounting display panels inside bulbs or envelopes of the type used in vacuum tubes. Such an arrangement is illustrated schematically in FIG. 22 which shows panel 10 in envelope 292 and supported therein in any suitable manner, for example, by the electrode strips. In this case, the plates of the panel need not be sealed together, but they can be held together by some mechanical clamping arrangement. The envelope 292 and thus the cells 30 of the panel are filled with the desired gas atmosphere through a tubulation 294. In addition, if desired in this arrangement, the top plate 72 and bottom plate 74 may be omitted if other means are provided to hold the electrodes in place on plate 20. With top plate 72 omitted, a problem, due to the possible deposition of sputtered cathode metal thereon, is avoided.

Since John McCauley's invention of the procedure, it has become standard practice in the gas display tube art to utilize mercury to minimize the sputtering of cathode metal. Mercury is provided in display panels by a novel process described and claimed in an application of G. A. Kupsky filed concurrently herewith. According to that invention, mercury is introduced by mounting a capsule 296 (FIG. 23) containing a droplet of mercury 298 in a glass tubulation 300 secured to one of the plates 72 or 74 of panel 10. The mercury capsule is placed relatively far, for example 2 to 3 inches, from the panel itself. The capsule 296 is either provided with a metal sleeve which can be heated by induction or with a wire 310, by which the capsule can be heated by means or current flow to cause it to break and release the mercury.

Referring again to the method of manufacturing a panel, after the glass plates which make up the panel have been assembled and sealed together, the panel is pumped out and baked out by way of the tubulation 300, and it is filled with a gas suitable for sustaining cathode glow. Gases such as argon and neon are suitable, with one satisfactory gas mixture comprising about 5 percent argon, 95 percent neon, and a trace of krypton. The gas pressure is in the range of about 40 to about 80 Torr at room temperature. After the panel has been suitably baked out and filled with its gas, the tubulation 300 is sealed off below the mercury capsule as at 320. The panel is then aged by cyclically firing each of the rows of cells in order, with about 50 to about 100 ma. of current flowing per row of cells. This aging step is carried out for a few hours.

Next, the mercury is released from its capsule 296 by means of heat applied to the capsule to cause it to crack and release the mercury. The mercury initially deposits on the wall of the tubulation 300 above the capsule, and, according to the invention, in order to force the mercury into all of the cells of the panel, the panel is baked in an oven to about 200° C.

Once a sufficient portion of the mercury has left the tubulation 300 and circulated through the cells, and preferably while the panel is being held at this elevated temperature, the portion of the tubulation containing the mercury capsule is removed, and the tabulation is sealed off at 330. The first aging step is then repeated.

If desired, the panel may first be heated to about 200° C., and then the mercury may be released from its capsule while the heating operation is maintained. As above, the tubulation is sealed off after the mercury has had time to spread through the panel and at the elevated temperature.

It is customary to use two or more aging steps for gas devices as described; however, this is not a requirement, and one step could be used.

Display panels embodying the invention may be rendered more versatile by the provision of auxiliary control electrodes to provide three or more electrodes for each cell. One device 332 of this type, referring to FIG. 24, is made up of a sandwich including a bottom glass plate 334 having a tubulation 336, horizontal row cathode electrodes 338, an insulation plate 340 having apertures 350 and associated sputter traps 351 as shown in FIGS. 1 and 2, column electrodes 352 having apertures 353, an insulating plate 356 having apertures 358 and sputter traps 359, row anode electrodes 360 having apertures 362, and finally a top glass plate 380. Various control actions can be achieved by means of potentials applied to the center electrodes 352 along with potentials applied to selected cathodes 338 and anodes 360.

Devices of the type described above can be rendered even more versatile by the inclusion of various light-producing phosphor materials in operative relation with the cells 30. Referring to FIG. 24 in which a single cell 30 is shown, phosphor material 390 may be coated on the top surface of cathode button 90 or in the depressions of a cup-shaped button, if used. The phosphor 390 may also be deposited on the wall of the cell 30 or on the inner surface of top plate 72 in alignment with the cell 30.

The phosphor may be deposited by painting, spraying, or by a settling process, as is well known, and any of the well known phosphors may be used as Sylvania Types 151, 161, 131, and various P-Types made by General Electric.

In one arrangement suitable, for example, for providing color displays, phosphors are used which generate the three primary colors, red, green, and blue, with the phosphors being deposited in adjacent cells to form color triads, as in color TV picture tubes and as illustrated schematically in FIG. **26.** A red-emitting phosphor is zinc phosphate activated with manganese; a green-emitting phosphor is zinc orthosilicate; and a blue-emitting phosphor is zinc sulfide.

It has been found that cells which include the well known zinc orthosilicate **P1** phosphor and a gas mixture including argon, neon, and xenon, can be operated to generate two different colors of light. When a relatively low voltage of approximately 300 volts is applied across a cell, the phosphor in the cell emits a generally green light due to ultraviolet excitation by the gas. If a higher voltage of approximately 400 volts is applied across a cell, the excitation is such that white light is emitted.

The gas filling which is particularly useful for generating color includes argon, neon, xenon, and mercury. Argon emits in the ultraviolet range to energize certain phosphors such as zinc sulphides and zinc oxides. Mercury also emits in the ultraviolet, and is particularly suited for energizing phosphors such as zinc sulfides and sulfates, and xenon, which also emits in the ultraviolet region, is particularly suitable for energizing oxide and silicate phosphors. It is also possible to utilize in a cell a first phosphor which can be energized by argon, neon, or mercury to emit ultraviolet light which energizes a second phosphor to emit the desired light. Typical phosphors for this type of operation include G. E. X–80 and JEDEC P–16 Types.

The panel **332** shown in FIG. **24** can also be provided with phosphor material. In particular, it can include two different phosphors in each cell, with one phosphor 400 provided in apertures **358** in plate **356** and another phosphor 410 provided in apertures **350** in plate **340.**

In operation of the device **332** with phosphors, assuming that it is desired to generate color from phosphor 410, then electrodes **352** are operated as anodes, and the electrodes **338** are operated as cathodes. Similarly, if it is desired to generate light from phosphor **400,** electrodes **360** are operated as cathodes with respect to the electrodes **352** as anodes. Assuming that phosphors **400** and **410** can be energized to combine and generate a third color, then this condition can be achieved either by operating both electrodes **338** and **360** at positive potentials as anodes, with the center electrodes **352** operated as cathodes at a negative potential, or vice versa.

Methods of operating matrix or panel devices which include arrays of electrodes as described are well known. In general, information to be displayed on a panel may come from a computer, decoder, or the like, and the signals received are applied to the proper X electrodes and Y electrodes, and the cells at the intersections of these electrodes turn on and display the desired information, which may be letters, numbers, characters, messages, pictures, etc. Display panels of the type described herein are particularly suited for operation by various methods set forth in a application of G. E. Holz and J. A. Ogle, Ser. No. 828,793, filed May 24, 1969, and a continuation-in-part thereof Ser. No. 850,984, filed Aug. 18, 1969.

As noted above, the multi-cell display panels described above represent a considerable advance in the art, and they provide essentially the first practical usable devices of their type which can be mass-produced in almost unlimited sizes. Many inventive features are embodied in the invention, and one of these resides in the structure of the apertured center plate and the anode and cathode electrodes, and in the relationship between these parts. This relates to the provision of slots in the top and bottom surfaces of the center plate and in the provision of projections on the anode and cathode electrodes in alignment with the cells.

Electrically, the provision of anode and cathode projections facing each other aids the establishment of a glow discharge. It also places the glow discharge around the cathode inside the cell and tends to prevent the possibility of crosstalk between cells. Mechanically, the projections on the electrodes provide a means for locating and seating the electrodes, and this is particularly critical for assembly of elongated, flexible, and relatively flimsy electrodes in large-size panels. The slots in the central plate also prevent crosstalk between adjacent rows or columns of cells since, in effect, a barrier is provided against the movement of ions or other particles. The slots also facilitate mounting of the anode and cathode electrodes on the central plate.

Another important feature of the invention is the provision of a substance which is photosensitive and emits electrons readily when stimulated by radiation. This feature assures rapid generation of a glow discharge. Methods of sealing together the parts of the panel and introducing mercury into the cells also contribute to the practical, useful aspects of the invention.

In view of the many embodiments and features of the invention, it will be clear to those skilled in the art that, within the scope of the invention, variations may be made in the various features described. For example, in a multi-cell panel, the invention does not require that the cells be provided in any particular physical arrangement, that is, in rows or columns, and, similarly, there is no requirement that the electrodes be set out in any particular array of relationship. In addition, materials such as glass, metals, phosphors, gases, may be varied, as may the various steps of assembling and processing multi-cell panels.

What is claimed is:

1. A cold cathode display panel comprising

an envelope containing a gas capable of generating light when energized electrically,

an insulating panel member in said envelope having a plurality of gas-filled apertures extending therethrough which comprise light-generating cells,

a plurality of electrodes in operative relation with said panel member,

selected ones of said electrodes including structural means comprising protrusions which enter said apertures and are shaped to match the cross-section of said apertures whereby they engage and interlock with said apertures so that said selected ones of said electrodes are in proper operative relation with said gas-filled cells and are uniformly separated from each other and are held in place with respect to each other and said panel member,

there being at least two electrodes engaging said panel member in contact with the gas in each cell, one of said two electrodes being operable as an anode and the other being operable as a cathode.

2. The panel defined in claim **1** wherein said cells have a generally cylindrical shape and said protrusions have a generally cylindrical shape.

3. The panel defined in claim **1** wherein said protrusions are cathode electrodes.

4. The panel defined in claim **1** wherein said protrusions are anode electrodes.

5. The panel defined in claim **1** and including light-emitting phosphor material deposited on said protrusions.

6. The panel defined in claim **1** and including light-emitting phosphor material deposited in each said cup-shaped cathode.

7. The panel defined in claim **1** and including a photocathode in each said cell.

8. A cold cathode display panel comprising

an envelope containing a gas capable of radiating energy when electrically energized,

an insulating panel member in said envelope having a plurality of gas-filled apertures extending therethrough which comprise light-generating cells,

a dish-like cathode electrode projecting into each said gas cell from one end thereof,

an anode electrode located near the opposite end of each said gas cell in physical contact with the gas in the cell,

means for energizing selected ones of said gas cells to produce light therein, said means including a first plurality of conductors each electrically interconnecting a plurality of said cathode electrodes and a second plurality of conductors, each electrically interconnecting a plurality of said anode electrodes,

said cathode electrodes being rigidly attached to said first plurality of conductors to facilitate the alignment of said cathode electrodes and said conductors with said gas cells,

each said projecting cathode being generally cup-shaped and including a central depression.

9. The panel defined in claim **8** and including a central post positioned within each said central depression.

10. The panel defined in claim **8** wherein each cell includes an electron-emitting photocathode.

11. The panel defined in claim **8** wherein each cell includes electron emitting photocathode material located in said central depression.

12. The panel defined in claim **8** wherein said anode electrodes are ribbon-like conductors which are narrowed in the region of each of the gas cells to permit viewing of the light generated within said gas cells.

13. The panel defined in claim **8** wherein said anode electrodes are ribbon-like conductors which include a plurality of apertures in the region of each of the gas cells.

14. The panel defined in claim **8** wherein the anodes are screen-like members.

15. The panel defined in claim **8** wherein each gas cell includes a phosphor material, and wherein said means for energizing selective ones of said gas cells serves to activate the gas of the selected cells which, in turn, activates the phosphor material.

16. A cold cathode display panel comprising

an envelope containing a gas capable of radiating energy when electrically energized,

an insulating panel member in said envelope having a plurality of gas-filled apertures extending therethrough which comprise light-generating cells,

a dish-like cathode electrode projecting into each said gas cell from one end thereof,

an anode electrode located near the opposite end of each said gas cell in physical contact with the gas in the cell,

means for energizing selected ones of said gas cells to produce light therein, said means including a first plurality of conductors each electrically interconnecting a plurality of said cathode electrodes and a second plurality of conductors, each electrically interconnecting a plurality of said anode electrodes,

said cathode electrodes being rigidly attached to said first plurality of conductors to facilitate the alignment of said cathode electrodes and said conductors with said gas cells,

the interior wall surface of each said gas cells being interrupted by a surface discontinuity located between the cathode and anode electrodes thereof.

17. The panel defined in claim **16** wherein the wall of each said gas cell is recessed between the cathode and anode electrodes to provide a discontinuous path for any material sputtered from said cathode electrode.

18. The panel defined in claim **16** wherein the first and second plurality of conductors are row and column conductors, respectively, and wherein said row conductors are elongated ribbon-like conductors with the cathode electrodes formed by elevations along the surface of said conductors in the regions of the successive gas cells.

19. The panel defined in claim **18** wherein said ribbon-like row conductors are wider than the corresponding transverse dimension of said gas cells and serve to close one end of the gas cells.

20. The panel defined in claim **18** wherein said cathode electrodes are tabs projecting from said ribbon-like conductors, which tabs are formed from portions of said ribbon-like conductors where said ribbons have been cut to provide the projecting tabs.

21. The panel defined in claim **20** wherein at least two tabs extend into each cell, the tabs in each cell being aligned at an angle with respect to those in adjacent cells.

22. The panel defined in claim **7** wherein the photocathode in each cell is supported on the wall of the cell.

23. The panel defined in claim **7** wherein each cell contains an electron-emitting photocathode including a compound of barium or cesium which provides free barium or cesium when the cell is aged.

24. The panel defined in claim **18** wherein said compound is a barium compound from which barium is released under particle bombardment in said cells.

25. A cold cathode display panel comprising

an envelope containing a gas capable of radiating energy when electrically energized,

an insulating panel member in said envelope containing a plurality of gas-filled apertures extending therethrough which comprise light-generating cells,

first and second phosphor materials within each of said cells,

at least three electrodes associated with each cell, two of said electrodes being located at opposite ends of the cell in physical contact with the gaseous atmosphere of the cell,

means for establishing an electrical potential between two of said three electrodes for stimulating one of said phosphor materials to produce a first color in selected ones of said cells, and

means for establishing an electrical potential between a different two of said three electrodes for stimulating the second phosphor material to produce a second color in selected ones of said cells.

26. The panel defined in claim **25** further including means for stimulating the two phosphor materials in selected cells simultaneously to produce a third color in selected ones of said cells.

27. The panel defined in claim **25** wherein at least one of said phosphor materials in each cell is located on the interior wall of the cell.

28. The panel defined in claim **25** wherein at least one of said phosphor materials in each cell is located on one of said electrodes.

29. A gaseous display device comprising

a central plate having a plurality of cells,

a top insulating plate and a bottom insulating plate in contact with said center plate and of larger surface area than said center plate,

cathode electrodes positioned between said center plate and said bottom plate,

anode electrodes positioned between said center plate and said top plate,

a flexible gasket surrounding said center plate and sealing the space between said top and bottom plates, and

a sealing material, between said top and bottom plates in the vicinity of said gasket, securing together all of said plates but prevented by said gasket from entering the space between said center plate and either of said top or bottom plates.

30. A cold cathode display panel comprising

an envelope containing a gas capable of radiating energy when electrically energized,

an insulating central panel member in said envelope having a plurality of gas-filled apertures extending therethrough which comprise light-generating cells,

a first boundary panel contiguous one surface of said central panel and a second boundary panel contiguous the opposite surface thereof, said first and second boundary panels having greater lateral dimensions than the lateral dimensions of the central panel,

a plurality of row conductors located between said central and first boundary panels and recessed in grooves located in one of said panels,

a plurality of column conductors located between said central panel and said second boundary panel and recessed in grooves located in at least one of said panels,

a gasket surrounding said central panel and disposed between said first and second boundary panels for forming a gas-tight seal,

cement material in the region of said gasket member and between said first and second boundary panels for maintaining said seal gas-tight.

31. A cold cathode display panel as in claim **30** wherein said row and column conductors are located in grooves in said first and second boundary panels, respectively.

32. The panel defined in claim **30** wherein said gasket is formed of compressible material and in uncompressed state and has a transverse dimension larger than the space between said first and second boundary panels.

33. The panel defined in claim **30** wherein said gasket is a rope-like member.

34. A cold cathode display panel comprising

an envelope containing a gas capable of radiating energy when electrically energized,

an insulating panel member in said envelope containing rows of grooves on one surface thereof and columns of grooves on the opposite surface,

said panel member having a plurality of gas-filled apertures extending therethrough, each extending between a row and a column groove and serving as a light-generating gas cell,

means for energizing selective ones of said gas cells to produce light therein,

said means including a first plurality of conductors extending along said row grooves and a second plurality of conductors extending along said column grooves for applying a predetermined electric field across selected ones of said cells,

said row and column conductors being in physical contact with the gaseous atmosphere of said gas cells,

said first conductors being generally rod-like in shape, and

a flexible sheet intimately engaging said rod-like conductors to prevent cross-talk between cells.

35. The panel defined in claim **34** wherein said sheet is fiberglass.

36. The panel defined in claim **34** wherein said rod-like conductors are positioned between two sheets of fiberglass intimately engaging said conductors to prevent cross-talk between cells.

37. The panel defined in claim **34** wherein said rod-like conductors are coated with insulating material except where they communicate with said gas cells.

38. A cold cathode display panel comprising

an envelope containing a gas capable of radiating energy when electrically energized,

an insulating panel member in said envelope having rows and columns of gas-filled apertures extending therethrough which comprise light-generating cells,

means for energizing selective ones of said gas cells to produce light therein,

said means including a set of row conductors bounding one side of said panel and a set of column conductors bounding the opposite side of said panel for applying a predetermined electric field across selected ones of said cells,

said row and column conductors being in physical contact with the gaseous atmosphere of said gas cells, and

a flexible sheet extending along the surface of said panel bounded by one set of said conductors and intimately engaging and enclosing said conductors to prevent cross-talk between said cells.

39. The panel defined in claim **38** wherein the conductors of said one set are rod-like and have a smaller transverse diameter than the transverse diameter of the cells.

40. The panel defined in claim 39 wherein said rod-like conductors are sandwiched between two flexible sheets, one of which lies contiguous the surface of said panel, and

wherein the flexible sheet contiguous to the panel is apertured in the region of each of said gas cells.

41. The panel defined in claim 38 wherein both sets of conductors are rod-like in shape.

42. A cold cathode display panel comprising

an envelope containing a gas capable of generating light when energized electrically,

an insulating panel member in said envelope having a plurality of gas-filled apertures extending therethrough which comprise light-generating cells,

a plurality of electrodes in operative relation with said panel member,

said electrodes including structural means comprising protrusions shaped to enter said cells and thereby to engage and interlock with said panel member so that said electrodes are in proper operative relation with said gas-filled cells and are uniformly separated from each other and are held in place with respect to each other and said panel member,

there being at least two such electrodes engaging said panel member in contact with the gas in each cell, one of said two electrodes being operable as an anode and the other being operable as a cathode.

43. The panel defined in claim 42 wherein said protrusions are generally cylindrical in shape and said cells are generally cylindrical in shape.

44. The panel defined in claim 42 wherein said panel member has a top surface and a bottom surface and all of the anode electrodes are disposed adjacent to said top surface and all of the cathode electrodes are disposed adjacent to said bottom surface.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,743,879 Dated July 3, 1973

Inventor(s) George A. Kupsky

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 37, delete "90. The" and insert -- a --.

Claim 6, line 1, change "1" to -- 8 --.

Claim 8, line 7, change "dish" to -- disk --.

Claim 16, line 7, change "dish" to -- disk --.

Signed and sealed this 26th day of March 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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